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Nanobiotechnology-Driven Ocular Delivery of Biologics Using Advanced Nanocarriers

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Abstract

Biotechnology is progressively advancing modern healthcare through the development of targeted, patient-friendly therapeutic strategies. Ocular diseases severely affect visual functions and quality of life, yet conventional drug delivery systems remain ineffective due to the unique anatomical and physiological barriers (cornea, sclera) of the eye. The Integration of nanobiotechnology offers a promising approach for enhancing the targeted delivery of biologics, including antibodies, peptides, and mRNA molecules, which possess high therapeutic potential but are hindered by stability, permeability, and bioavailability challenges. Advanced nanocarrier systems, including liposomes, emulsions, nanostructured lipid carriers, and polymeric nanoparticles, are being explored as they address these challenges by improving corneal permeability, protecting biologics from enzymatic degradation, and enabling sustained and localized delivery to both the anterior and posterior segments of the eye. These nanosystems effectively enhance therapeutic residence time, facilitate controlled release, and reduce systemic exposure, therefore improving patient compliance and treatment outcomes. This highlights recent advances in nanocarrier-mediated ocular delivery strategies that represent the principles of transformative biotechnology in healthcare. Therefore, integration of nanotechnology with biologically active therapeutics offers safer, more effective, and patient-centric alternatives, thereby reshaping the future of ocular disease management.

Keywords: Ocular delivery, Nanobiotechnology, Biologics, Nanocarriers, Corneal permeability, Bioavailability

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